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SAFETY VALVE
[SICHERHEITSVENTIL]

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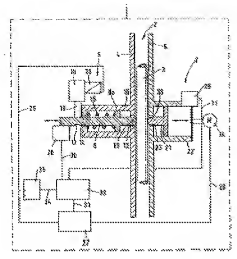
Safety valve

A safety valve for a flexible tubing, especially the venous blood duct of a hemodialyzer, has a first shut-off element (8) and a holding element (16); the shut-off element can be elastically pre-stressed against the flexible tubing (3) at a position at which the tubing is pinched off; the shut-off element can be arrested with the holding element at a position which releases the tubing. Moreover, a second shut-off element (21) is provided. Lay-on surfaces are provided for the tubing (3) on the areas opposite to the shut-off elements in such a way that the flexible tubing (3) can be unclamped from both the shut-off elements (8, 21) independent of each other. The second shut-off element (21) works not only as an independent clamping function, but, it is also used to push back the first shut-off element (8) against the spring force in the position which releases the flexible tubing; in this position, the first shut-off element (8) can be arrested with the holding element (16).



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Description

The invention relates to a safety device for a flexible tubing, especially the venous blood duct of a hemodialyzer.

Known hemodialyzers provide a safety valve in the venous blood duct of extracorporeal blood circulation for protecting the patient against air infusion and non-physiological pressure ratios. In case of error, the safety valve is closed automatically such that the extracorporeal blood circulation is interrupted.

Known safety valves are designed as rotary switches whose rotational axis has a circular section-shaped recess to

accommodate the flexible blood duct in the clamping area. The rotational axis is elastically pre-stressed in the clamping position of tubing. During the working of the hemodialyzer, the rotational axis is retained in the open position with the help of an electromagnet. If the electromagnet is not supplied with current in case of error, the rotational axis goes back to its original position quickly due to the restoring force, by which the blood-supplying tube is clamped. The clamping of tube has the advantage that the extracorporeal blood circulation is interrupted immediately in case of disruption; a relatively strong magnet with high power consumption is required for holding the rotational axis in the open position; this magnet is heavy and has a large heat build-up.

A1 describes a safety valve for clamping an elastic tubing with a shut-off element which can be fixed against the tube by means of a spring element. The safety valve has a holding element with which the shut-off element can be retained in its pulled-back state. A draw-in element is provided for pulling back the shut-off element. The draw-in element consists of a memory- metal which shortens itself when heated with an electrical heating apparatus.

EP 0 624 382 A1 publishes a safety valve which uses a gripping cam for shutting off the flexible tubing.

US 4 176 671 describes a safety valve which has two shut-off elements opposite to each other; the tubing to be clamped is placed between them. The first shut-off element uses an electromotive drive, while the second shut-off element is fixed against the tubing by means of a spring element. The second shut-off element is to hold the flexible tubing clamped constantly during the common alternating motion of both the elements. In order to open the valve, the first shut-off element must be fully lowered and thus the spring element of the second shut-off element is pressed together. As soon as the second shut-off element has experienced its maximum deflection, it is retained in this position connected by means of an electromagnet. After that, the first shut-off element returns and releases the flexible tubing. Both the shut-off elements must ensure that the valve can be opened or closed very quickly.

The disadvantage is that failure of the first shut-off element in the opened position leads to non-closure of the entire valve. This is due to the fact that the second shut-

off element alone is not suitable to clamp the flexible tubing.

The task of this invention is to develop a safety valve for a flexible tubing, especially for the venous blood duct of a hemodialyzer which makes use of two independent working mechanisms with which the flexible tubing can be pinched off by which the risk of air infusion or the like is reduced.

The solution to this problem is given in the characteristics of Patent claim 1 or 13 as per the invention.

The inventive safety valve has two independent working mechanisms for pinching off the flexible tubing. The first working mechanism comprises a shut-off element which is elastically pre-stressed against the flexible tubing in a pinched off position of the tubing and a holding element with which the shut-off element can be arrested in a position at which the flexible tubing is released. The second working mechanism comprises a second shut-off element as well as an activation device for adjusting the second shut-off element between the clamping position and

the release position. Both the working mechanisms are based on the fact that the shut-off element presses the flexible tubing against the opposite lay-on surface. In this way, the tubing is clamped.

The clamping of the tubing is possible with the second shut-off element if the readjusting spring of the first shut-off element must be broken. The second shut-off element not only works as an independent clamping device but also helps in bringing back the first shut-off element in the position at which it can arrest with the holding element. Since the re-positioning of the first shut-off element does not take place with the holding element, but with the second shut-off element, the holding element needs to take over only the arresting function so that the power consumption is low in the open position.

In a preferred embodiment of the invention, the first and the second shut-off elements have gripping jaws that can be moved in the longitudinal direction; these are arranged in such a way that they can be moved opposite each other on a common axis. In principle, the shut-off elements can even be deflectable gripping parts. The gripping jaws have the advantage that a relatively large stroke can be produced

such that even flexible tubings of large diameter can be clamped or completely opened.

In order to adjust the second shut-off element, the activation device has preferably an electromotive drive. The second shut-off element can be brought to any arbitrary clamping positions with this drive and the cross-section of the tube can be correspondingly reduced.

In another preferred embodiment, a recess is provided in the first shut-off element in which the holding element can be latched for arresting the first shut-off element in the tubing-release position. The holding element is preferably elastically pre-stressed in the position at which the first shut-off element is released.

In another preferred design, a device is provided for monitoring the position of the first and/or the second shut-off element in order to be able to take up a functional check of the safety valve. An evaluation device is connected to this monitoring device in such a way that the position of the first or second shut-off element indicates whether the tubing is between the shut-off elements. Moreover, the diameter of the flexible tubing can

be determined with the help of the position of the shut-off element given by the monitoring device.

An alternative embodiment of the safety valve which is the objective of Claim 13 has a monitoring device which monitors the position of the first and the second shut-off element; a guide for the flexible tubing is not necessarily

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quired for this embodiment of safety valve. An evaluation device is connected to the monitoring device such that the position of the first and second shut-off element decides whether a flexible tubing is arranged between the shut-off elements or even to determine the diameter of the flexible tubing.

The inventive safety valve is used especially for clamping the venous blood duct of a hemodialyzer. Another application of this safety valve is in infusion devices with which medicinal fluids can be administered to the patient. It can be used even in other technical fields in which an elastic fluid -or gas tube must be alternatingly opened and closed.

An embodiment of the invention and reference to the drawing is explained below; the safety valve is shown in a simplified schematic presentation.

The safety valve has a housing 1 with a guide 2 for accommodating the flexible tubing 3. The guide 2 is made up of two plates 4,5 at a distance from each other. The guide can be designed even as pipes through which the flexible tubing can be guided.

A first shut-off element 6 is provided on one side of the guide 2, while a second shut-off device 7 is provided on the other side of the guide; the flexible tubing 3 can be clamped with these independent of each other; the tubing can be inserted in the guide 2.
The first shut-off device 6 has a cylinder 18 which is connected to the guide plate 5. A first shut-off element 8 is guided transverse to the longitudinal axis of the tube in the cylinder 18 movable in the longitudinal direction. The first shut-off element is a bar whose front end piece forms a gripping jaw 13 which stretches through a bore 12 in the guide plate 5. The rear end piece of the bar stretches through a bore 14 on the floor of the cylinder towards the outside. The first shut-off element 8 is

elastically pre-stressed against the flexible tubing 3 with the help of a coil spring 15; this coil spring rests on a ring-shaped shoulder 8a of the shut-off element on one side and rests on a cylinder bottom on the other side.

The first shut-off element 8 is held in the position which releases the flexible tubing from a holding element 16; this holding element is designed in the shape of a bell. The first shut-off element 8 has a recess 17 with a sloping surface in the direction of front end towards the outside at its rear end. The holding element 16 is guided transverse to the longitudinal axis of the shut-off element and it has an appropriate sloping area and can grasp the shut-off element in the drawn-back position in the recess 17 at its rear end piece.

The holding element 16 is elastically pre-stressed in the position at which the first shut-off element 8 is released. A release device 19 is provided for activating the holding element 16; this release device makes use of an electromagnet 20 which holds the holding element in the recess 17. If the electromagnet 20 is not supplied with current, the holding element 16 goes back quickly by which the first shut-off element 8 is released. The flexible

tubing 3 is pressed against the opposite guide plate 5 of the guide 2 due to the restoring force of the coil spring 15. The coil spring 15 is designed in such a way that the tube is clamped completely.

The second shut-off device 7 has a second shut-off element 21 which is guided on the same axis as that of the first shut-off element movable in the longitudinal direction in a cylinder 22 connected to the guide plate 4. The front end piece of the second shut-off element 21 forms a gripping jaw 36 which stretches through a bore 23 in the guide plate 4. The second shut-off element 21 is activated by means of an electromotor 24 such that the cross-section of tube 3 can be reduced arbitrarily by pressing against the guide plate 4. In the same way, the second shut-off element 21 helps in re-setting the first shut-off element 8.

The electromagnet 20 of the release device 19 and the electromotor 24 are connected to a central control device 27 via the control circuits 25, 26. Further, the first and the second shut-off devices 6, 7 have position sensors 28, 29 with which the position of the shut-off elements 8, 21 can be recorded. The position sensors 28, 29 are connected to an evaluation unit 32 via data links 30, 31 which are

connected to the control unit 27 via a data link 33. An alarm emitter 35 is connected to the evaluation unit 32 via a data link 34.

The function of a safety valve is described in detail below.

The first shut-off element 8 is held by the holding element 16 in the position at which the flexible tubing 3 is released. This position is shown in the figure. In case of error, the power supply of the electromagnet 20 of the release device 19 is interrupted such that the first shut-off element 8 is released and the flexible tubing is clamped against the guide plate 5. The electromotor 24 of the control unit 27 is set into motion for pushing back the first shut-off element after the termination of error such that the second shut-off element 21 is advanced in the direction of the first shut-off element 8. While the second shut-off element 21 is moved forwards, it pushes against the first shut-off element 8 which has clamped the flexible tubing 3 and the first shut-off element pushes back against the restoring force of the coil spring 15 in case of the clamped flexible tubing till the holding element 16 locks in the recess 17 of the first shut-off element. The holding

element 16 is held by the electromagnet 20 in the position at which the first shut-off organ is arrested.

This electromagnet is controlled by the control unit 27. If the position sensor 28 has reached this position, the control device 27 turns the sense of rotation of electromagnet 24 such that the second shut-off element 21 goes back again to the position at which the flexible tubing is released.

The position sensors 28 and 29 record the positions of the shut-off elements 8 and 21, possibly with displacement sensors. To determine whether a flexible tubing 3 is within the guide 2, the control device 27 controls the shut-off elements 8, 21 as follows.

One of the two shut-off elements 8 or 21 is moved into the guide 2 as much as possible. This takes place by disconnecting the power supply for electromagnet 20 of the shut-off element 8 such that the holding element 16 releases the shut-off element 8. The other shut-off element is not traversed, i.e. it does not project into the guide. The current position sensor 28, 29 measures the distance which is covered by the traversed shut-off element till it

has experienced the maximum possible deflection. The position sensor 28, 29 forwards the data to the evaluation unit 32 via a data link. The evaluation unit 32 compares the distance traversed by the shut-off element with the

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distance of the guide plates 4, 5. If the latter one is greater than the traversed distance, then, the flexible tubing is found in guide 2. The tubing set can be identified, if necessary, from the recording of distance of both the gripping jaws. If the paths have the same lengths, the alarm emitter 35 emits an alarm in order to indicate that no flexible tubing runs in the guide.

In order to determine the diameter of the flexible tubing 3 which runs between the guide plates 4,5, the control device 27 controls the shut-off elements 8, 21 in such a way that these are driven up to the flexible tubing 3 without pressing together the flexible tubing 3. The evaluation unit 32 calculates the diameter of the flexible tubing 3 from the position of the shut-off elements 8, 21. This is displayed on an output device (not shown).

If no guide is provided, the determination of existence of flexible tubing as well as its diameter takes place as

follows. One of the two shut-off elements 8 or 21 or even both are driven in the direction of the other shut-off element as far as possible. The position sensors 28, 29 measure the distance which is traversed by the shut-off elements till these have experienced the maximum possible deflection. The position sensors 28, 29 forward the data to the evaluation unit 32 via a data link. The evaluation unit 32 determines the distance between the shut-off elements 8, 21 from the paths traversed by the shut-off elements. If the latter one is greater than null, a flexible tubing is found between the shut-off elements 8, 21. If the gripping jaws 13, 36 are directly adjacent to each other, i.e. the distance is null, there is no flexible tubing between the shut-off elements 8 and 21. In order to determine the diameter of the flexible tubing 3 which runs between the shut-off elements 8, 21, the control device 27 controls the shut-off element 21 in such a way that it is driven up till the flexible tubing 3 without pressing together the flexible tubing 3. The shut-off element 8 takes over the role of the guide, i.e. it forms the immovable counter body. The evaluation unit 32 calculates the distance between the shut-off elements from the position of the shut-off elements 8, 21. This is displayed on the output device which is not shown.

Patent claims

1. Safety valve for a flexible tubing, especially venous blood duct of a hemodialyzer, provided with a first shut-off element (8) which is elastically pre-stressed against the flexible tubing in a position at which the flexible tubing is clamped, and a holding element (16) with which the shut-off element can be arrested in a position that releases the flexible tubing., whereby a second shut-off element (21) and an activation device (24) are provided for adjusting the second shut-off element between the positions of clamping the flexible tubing and releasing the flexible tubing, characterized thereby, that lay-on surfaces (4,5) are provided on the areas opposite the shut-off elements (8, 21) such that the flexible tubing can be clamped with both the shut-off elements (8, 21) independent of each other.

2. Safety valve according to Claim 1, characterized thereby, that the lay-on surfaces (4, 5) are part of a guide (2) for accommodating the flexible tubing.

3. Safety valve according to Claim 2, characterized thereby, that the guide (2) comprises two guide plates (4, 5) that are parallel to each other which have a

bore (23, 12) through which the shut-off element (21, 8) is stretched.

4. Safety valve according to one of the claims 1 to 3, characterized thereby, that the first and the second shut-off element (8, 21) have gripping jaws (13, 36) that can be moved in the longitudinal direction; these jaws are arranged on a common axis such that they can be moved against each other.

5. Safety valve according to one of the claims 1 to 4, characterized thereby, that the activation device (24) has an electromotive drive for adjusting the second shut-off element.

6. Safety valve according to one of the claims 1 to 5, characterized thereby, that a recess (17) is provided in the first shut-off element (8) in which the holding element (16) can be latched for arresting the first shut-off element in the position which releases the flexible tubing.

7. Safety valve according to Claim 6, characterized thereby, that the holding element (16) is elastically pre-stressed in the position which releases the first shut-off element (8).

8. Safety valve according to Claim 7, characterized thereby, that a release device (19) is provided for activating the holding element (16).

9. Safety valve according to Claim 8, characterized thereby, that the release device (19) can be activated electromagnetically.

10. Safety valve according to one of the Claims 1 to 9, characterized thereby, that a device (28, 29) is provided for monitoring the position of the first and/or second shut-off element (8, 21).

11. Safety valve according to Claim 10, characterized thereby, that an evaluation unit (32) is connected to a monitoring device (28, 29) designed in such a way that the position of the first or the second shut-off element (8, 21) indicates whether the flexible tubing is arranged between the shut-off elements.

12. Safety valve according to Claim 11, characterized thereby, that the evaluation unit (32) is designed in such a way that the diameter of flexible tubing (3) can be determined from the position of the shut-off element (8, 21) which is determined by the monitoring device (28, 29).

13. Safety valve for a flexible tubing, especially the venous blood duct of a hemodialyzer, provided with a first shut-off element (8) which is elastically pre-stressed against the flexible tubing in a position at which the flexible tubing is clamped, and a holding element (16) with which the shut-off element can be arrested in a position that releases the flexible tubing; whereby a second shut-off element (21) and an activation device (24) are provided for adjusting the second shut-off element between the positions of clamping the flexible tubing and releasing the flexible tubing, characterized thereby, that a device (28, 29) is provided for monitoring the position of the first and second shut-off element (8, 21) which is connected to an evaluation unit (32) which is designed in such a way that it can be determined from the position of the first and second shut-off element (8, 21) whether a flexible tubing (3) is arranged between the shut-off elements or to determine even the diameter of this flexible tubing (3).

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1 page(s) of drawing attached herewith

DRAWINGS PAGE 1

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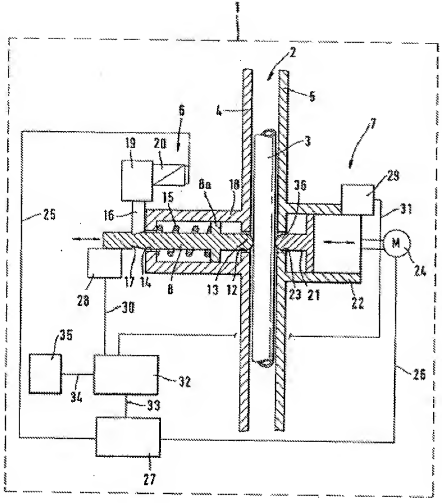
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